

QuarkNet Center @ Colorado State University

FY1 Annual Report

Faculty mentor: Dr. Miguel Mostafa, Associate Professor, Physics Department, Colorado State University.

Lead Teachers: Cherie Bornhorst, Science Teacher, Loveland High School; and Adam Pearlstein, Science Teacher, Denver Jewish Day School.

Setup and Calibration of Cosmic Ray Muon Detectors

The first week of the new QuarkNet @ CSU was dedicated to the Cosmic Ray e-Lab. The three-day e-Lab was led by Bob Peterson from Fermilab. The main component of the e-Lab was the assembly and implementation of two Series 6000 Cosmic Ray Muon Detectors (CRMDs), 6775 and 6776. There were three dedicated seminars during the e-Lab: one on Ultra-high energy cosmic rays by Prof. Miguel Mostafa, another about neutrino experiments by Prof. Robert Wilson, and the third one about Nanotechnology by Prof. Kristen Buchanan, all three faculty from CSU Physics Department. The participants of the e-Lab were Cherie Bornhorst and Adam Pearlstein (QuarkNet @ CSU Lead Teachers), plus six high school Physics teachers from the Northern Colorado area. (A complete list of participants is included in the attached spreadsheet.)



Figure 1: High School Science Teachers setting up two Muon detectors. Both laptops are inclusive part of the detector sets that went to the schools.

Participants built both CRMDs, learnt about cosmic rays and muon fluxes, took data with their detectors, and did some basic analysis. Two new Dell laptops were purchased with the PI funds and were made part of the CRMDs that went to the schools. Both laptops were set up to dual boot Windows and Ubuntu Linux, each operating system equipped to interface with the CRMD DAQ. Additional resources (tutorials, instruction guides, etc.) were created and loaded on the notebooks and synced via Dropbox.

During the e-Lab, the CRMDs were voltage calibrated using the method of two-fold coincidences, and used to find plateau of counts. The calibration was verified using a performance study on the Cosmic Ray e-Lab, and the voltages were adjusted to keep counts between channels consistent.

Both detectors are currently deployed at two Colorado high schools: Loveland

High School in Northern Colorado and Denver Jewish Day School in Central Colorado.

Follow-up from the e-Lab

One of the CRMD detectors, 6775, was taken to the Oglala Lakota College on the Pine Ridge Indian Reservation in South Dakota, where it was used to collect data during a weeklong teacher workshop. Both detectors were used again late summer in an additional two-day workshop with the same six high school teachers that participated in the e-Lab. This two-day workshop was led and organized by Bornhorst and Pearlstein. The main goal was to give the teachers an in-depth practice with the detectors and the Cosmic Ray e-Lab. The workshop was complemented with lectures in high-energy physics from two CSU faculty members.



Figure 2: QuarkNet CRMD at the Oglala Lakota College on the Pine Ridge Indian Reservation in South Dakota.

During the summer the lead teachers also created a simple cloud chamber for visualizing cosmic rays. The cloud chambers were made with materials that the high school teachers could get readily and affordably. The cloud chambers were presented to the local section of AAPT, and also to the teachers at the Pine Ridge Reservation in South Dakota.

Future plans

As mentioned before, both CRMDs are deployed at Colorado high schools, one in Loveland (Northern Colorado) and the other one in Denver. High school students will use both detectors, and they will be incorporated into the science curriculum.

Using the connections made during the Cosmic Ray e-Lab, there are already concrete plans in place to share the detectors during the school year with Fort Collins High School (near CSU), and Castle Ridge High School in Central Colorado. Next year teachers will participate in a dedicated workshop on the water Cherenkov detection technique, and they will get to use the full-size prototype at CSU for the High Altitude Water Cherenkov Observatory.

Teachers will continue to use the CRMDs. There are plans for dedicated campaigns to measure muon fluxes as a function of zenith angles, incoming directions, and times of the day. Colorado also offers the perfect laboratory to study muon fluxes as a function of altitude, reaching possible sites at 14,000 ft.

The lead teachers will also share their experience building cloud chambers with science teachers at the upcoming Colorado Science Conference in November.